

HISTORY AND DEVELOPMENT OF THE

WASHINGTON TERMINAL

POWER PLANT

Samuel Letvin

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SUMMARY

The Main Power Plant of the Washington Terminal is a modern, well equipped efficient source of power. It is unique in that it produces power for a multitude of uses such as lights, electric motors, refrigeration, air cleaning, compressing, etc.

The design, layout, installation, and selection of machinery and the building is a credit to the designers , manufacturers and contractors as they present the best that could be had at that period of the construction of the Terminal. All units have given extremely satisfactory service. This, in the fact that the load on the plant is constant has made it possible that there be no major changes in the original equipment or layout.

Also the near future indicates no major change will be necessary.

HISTORY AND DEVELOPMENT OF THE WASHINGTON TERMINAL POWER PLANT

The Washington Terminal Power Plant, constructed at the time of the building of the Union Station is composed of three separate units. The main plant adjoining the Union Station proper, the coach plant at Eckington and the shop plant at Ivy City. This paper will deal with the main plant.

These three power plants make the Washington Terminal independent of any outside source of electricity for lighting, or motors, of steam for heating, compressed air used in cleaning, brake testing and electro-pneumatic signals, water for drinking, house service and fire protection.

The plant was designed and laid out by B. F. Wood, then Asst. Mechanical Engineer of the Pennsylvania Railroad Company. The plant was constructed in 1907 and is of masonry and steel construction. It was built under the supervision of the engineers of that railroad, by the James Stuart Company of New York, who performed all the work of construction except the steel work, which was furnished and erected by the American Bridge Company of New York.

At the time of its construction the plant was considered one of the best designed and equipped power plants of that type.

The site of the plant was picked mainly for economic reasons, that the plant be near enough to the terminals of its power without undue loss in transmission and not to

interfere with the rest of the functions of the Terminal. A better site could not have been picked.

The soil upon which the plant is placed gave the contractors a great deal of trouble as it is soft and water was encountered about fifteen feet below the surface. First, concrete piling attempted by the Simplex Method, proved a failure, due to a quantity of sand and water entering the tubes and not allowing the necessary amount of concrete to be poured. The last resort was to drive wood piles, which proved successful. A total of 191 piles of wood were driven. The housing of the plant occupies a space of 77'x238'.

The plant is equipped with four Westinghouse Parsons turbines running at 3600 R. P. M., three velocity stage, and condensing. They are directly connected to four Westinghouse A. C. generators of 500 K. W., 2300 volts, three phase, sixty cycles and 120 amperes / terminal. Two turbines and their two generators are generally enough to take care of the load.

For exciters there are two 50 K. W. direct current machines and are driven by induction motors direct connected. These were furnished by Westinghouse. There is also a thirty-five K. W. D. C. exciter used in emergency, driven by a compound engine, also from Westinghouse.

In 1926, a D. C. exciter run by an induction motor, direct connected with a Terry Steam turbine as a reserve, also direct connected was purchased and is now used for the field excitation. This machine was installed by the North Western Manufacturing Company. Its normal speed is 1740 R. P. M.

The two 50 K. W. exciters are often used as D. C. generators to drive the machines in the basement shop.

The four turbines have given extremely satisfactory service and today are as good as when first installed. Each year these machines have their blading inspected and straightened. During 1924 and 1925 all the turbines were sent back to the Westinghouse factories, one at a time, to be rebladed and relined. No difficulty was experienced in taking care of the load at the plant by this repairing. On the engine room floor there is room for two more turbines, but due to the load being constant there is no expectation of there ever being installed.

There are seven 420 H. P. Babcock-Wilcox water tube, semi-marine, boilers equipped with seven chain grate stokers and seven superheaters. The settings are fashioned like the Dutch oven furnace construction, having unusually high combustion chambers, which are 22' above the boiler room floor. Reinforced concrete ash hoppers and waste coal pockets are incorporated in the floor construction.

There is room for three more boilers, but as in the case of the turbines, there is no apparent future need for them. From 1926 to 1929 all the brick work in the boilers was rebuilt. The plant was not at all inconvenienced by this.

During this period of relining and in connection with this, Professor J. N. G. Nesbit of the University of Maryland made some tests on these boilers to see if they could take care of the terminal load plus the load at the Eckington

plant, while those boilers were also being rebuilt. The first test on one boiler showed that 8.63 # water / # of coal was being evaporated and the boiler could only be rushed 48% over its capacity. This boiler was relined with a higher resistive firebrick, and the combustion chamber enlarged. These factors increased the capacity of the boilers 100% and made possible the use of the Terminal boilers to supply the Eckington plant with steam and also carry their own load. The Eckington plant boilers were equipped with new firebrick and their combustion chambers enlarged, and during this repairing the Terminal boilers took care of the excess load.

This makes it possible at the terminal to use 50% of their boiler capacity to take care of the normal load; thus permitting them to use only a part of the boilers at a time.

The Green Fuel Economizer Company of Mattewan, New York, installed seven improved patented fuel economizers instead of the usual single large unit economizer interposed in the main flue connection of the stack. These are divided into two groups, three in one and four in another. Each group is operated by a 10 H. P. induction motor. Each group is designed to take care of five units eventually in anticipation of the possible addition of three more boilers.

Two feed water heaters were made and installed by the Harrison Safety Boiler Works including the Sorge Cochrane System of water purification. This apparatus is especially designed and adapted for use of any steam heating or drying system under vacuum or back pressure. In addition to per-

forming the regular functions of an open or direct contact feed water heater, it provides for the reception and heating of the condensation from the heating system.

The Nordberg Manufacturing Company of Milwaukee, Wisconsin, built and installed on foundations furnished by the Terminal two horizontal, heavy duty, cross compound, non-condensing, poppet valve, pumping engines having a 24" stroke, a piston speed of 300' / min. under a steam pressure of 150#. These engines will pump 750 gallons / min. against a pressure of 300#.

The coal and ash handling apparatus was built and installed by C. W. Hunt of New York. The coal is delivered to the plant in regular drop bottom coal cars, and dumped into a fifty ton hopper from where it passed to the crackers and thence by belt conveyors to be stored in the bunkers in the upper part of the boiler room.

The coal used is a semi-bituminous grade running about 14,000 B. T. U. / # of coal, and at present comes from the Consolidated Coal Company and is mined in Somerset County, Pa. The average quantity of water evaporated / # of coal is 10 # water / # coal. At present the plant uses about 24,000 tons monthly.

No other fuel is used or has ever been used except semi-bituminous coal.

Two air Compressors were built and installed by the Nordberg Manufacturing Company. They are each cross compound, two stage, Nordberg-Corliss air compressors. There is a tubular inter-cooler above and between the air cylinders

fitted with seamless brass tubes and providing 450 square feet of cooling surface to cool the air discharged from the low pressure to the high pressure cylinder. They are capable of compressing 1,500 cu. feet of free air / min. to a pressure of 100 #. One is generally run at a time. They furnish compressed air at 100 # for the operation of the electro-pneumatic signals and testing air brakes on passenger cars in the train yard. Also they furnish two Franklin compressors with air to be raised to 300 # to be used in the elevator system.

The Epping-Carpenter Company of Pittsburg, Pennsylvania installed on foundations furnished by the Terminal two 16x10x16" duplex boiler feed pumps, two 12x8x16" duplex boiler feed pumps for building service and two 18x10x12" underwriter fire pumps by the G. F. Blake Manufacturing Company. The boiler feed pumps are capable of delivering 600 gallons of water / min. at a piston speed of 75' / min. and 300 # pressure. The building service pumps will deliver 350 gallons / min. at 67' / min. at 300 #. The fire pumps are capable of delivering 1,000 gallons / min.

The Cooling Tower and Surface Condenser Equipment was furnished and erected by the H. R. Worthington Co. of New York, which consists of a cooling tower and necessary surface condensing apparatus for the power house. The cooling tower is of brick with a concrete foundation capable of cooling the circulating water required to condense 30,000 # of steam / hour. and maintain in the condensing apparatus a 26" vacuum and 30" barometer at a temperature of 75 degrees and 75%

relative humidity. A cistern in the base of the tower for taking care of the cooled water is water proofed with a hydrolithic compound furnished by the E. J. Winslow Company of Chicago, Illinois. It is equipped for forced air circulation with four 96" disk fans driven by two 40 H. P. Westinghouse induction motors.

The condensing apparatus which is immediately beneath the turbines consists of four surface condensers, one for each turbine, two 8x16x12" vertical double acting air pumps of suction valveless type, two 14" horizontal special volute centrifugal circulating pumps and two $7\frac{1}{2} \times 7\frac{1}{2} \times 6$ " horizontal duplex low service piston pattern pumps.

Each circulating pump can deliver 4,400 gallons of water / min. against a 50' head when operating at 325 R.P.M. They are operated by 10x18x10" Westinghouse compound engine. The apparatus is arranged so that each turbine has an individual condenser. The vacuum pumps are arranged and proportioned so that each can take care of two units. The service or hot well pumps are proportioned so that each can take care of the entire load of the turbines which is 48,000 # steam / hour.

The refrigerating plant was furnished and erected by the Carbondale Machine Company of Carbondale, Pennsylvania. It has a normal cooling capacity equal to that of the melting of 50 tons of ice every 24 hours. It is capable of cooling from 75 degrees to 40 degrees Fahrenheit and circulating 600 gallons of drinking water / hour, cooling

30,000 cu. feet of refrigerator space to 38 degrees Fahrenheit, 10,250 cu. feet of mortuary chamber to 32 degrees Fahrenheit and freezing 50 gallons of ice cream.

A ten ton Niles Bement-Pond Company, three motor, electric traveling crane, is used in the engine room.

The chimney for the power house stack was built by the Alphons Custodis Chimney Company of New York. A creek running at the base of the chimney had to be obliterated when it was constructed, in order to lay the stack foundation properly. At the base of the chimney there are two blow off tanks 12 feet long and 57" in diameter connected to the boilers. Each tank has a capacity of 1,750 gallons.

The piping systme of the plant was furnished by the W. K. Mitchell Company of Philadelphia, Pennsylvania, while the pipe covering was furnished by Phillip Carey of Lockland, Ohio. A 85% magnesia sectional covering was used throughout.

The conduits and lighting fixtures were furnished by A. S. Schulman Company of Cincinnati, Ohio.

The Westinghouse Company furnished and erected one alternating current switch board, one direct current exciter switch board, one direct current Brush arc switch board, two switch boards for storage battery charging sets and four Brush arc machines used in lighting the arc lamps. The Brush arc machines were removed during the period of 1917 to 1920 and sold when the arc lights were changed to alternating current lights. The old arc switch board still stands at the south end of the engine room.

The personel of the plant consists of one Chief Engineer, one Refrigerating Engineer, one foreman, one water tender, one switch board operator, one oiler, one conveyor man, and two coal passers. On the night shift there is one foreman, one switch board operator, one water tender, one fireman and two oilers.

When the plant first began operating, Mr. J. B. MacIntosch was Chief Engineer. In 1913, Mr. Foultz took charge of the plant until 1917 when G. F. Harbin took over the reins and remained Chief Engineer until 1919, when Mr. Foultz returned and he is in charge at present.

In 1914 acting on Mr. Foultz's advice, two synchronous motors and one in 1929 were installed in the Express Building. This installation illustrated the principle in which synchronous motors can be added to a circuit without over-loading the generators, as they increase the power factor in the circuit, since a synchronous motor produces capacity in a circuit which counteracts the inductance produced by the induction motors. The increase in load is thrown however on the turbines.

The water supply of the plant is obtained from two sources, the District of Columbia Water Works and three artesian wells situated upon the terminal property.

Two of the wells are 200' deep and the other is 100' deep. Due to the close relation of the rest of the Terminal with the power plant, an accurate check on the water used is not possible, but on estimation it runs as

low as 127,000 cu. feet / month and as high as 209,000 cu. feet / month. The average is 170,000 cu. feet / month. The water from the wells due to its increased coolness is used monthly in the condensating apparatus.

As the water from the wells and the District water have a minimum of harmful minerals and in consequence very little boiler scale is formed.

In 1925 the well which is 100' deep was cleaned and overhauled so that its original output could be maintained. This action did not prove successful as it is still below its normal output. There is no regular period for inspection and overhauling at the plant. The machinery is tended and watched daily, and overhauled when necessary. Once a month the lockers of the men, clothes, tools and things in general are inspected and checked.

The plant has now been in operation for twenty-two years and the major portion of the equipment is still intact and operating efficiently. There has as yet been no major change or addition either to the plant or its equipment. Of course there have been replacements of worn or broken parts of the machinery, but the shape of the equipment is excellent and shows no signs of age, and probably will be replaced only as they become extremely out of date.

Among the important changes have been in the pumps, during 1924 to 1925, the two Westinghouse compound engines on the condensing apparatus and their snail shell centrifugal pumps were replaced by a small, high speed Fairbanks-Morse

centrifugal pump of the same capacity driven by a Terry turbine and a Fredrick centrifugal pump driven by an induction motor. The old pumps were removed as they were getting inefficient, uneconomical and took up a great deal of space.

Now the steam turbine pump is run in winter and the exhaust steam used for heating--incidentally the whole station is heated by exhaust steam tempered with enough live steam--and the motor driven pump is run in the summer, thus making a very economical arrangement.

Also the Epping-Carpenter pumps were changed in 1927 to Allis Chalmers Centrifugal pumps motor driven and in 1928 the building service pumps were replaced by Terry turbine driven centrifugal pumps. The old units were replaced due to depreciation.

The fact that there have been no major replacements or changes in the plant speak well for the original design and the twenty-two years of maintenance. But the main reason is that the loads on the plant have been constant due to the nature of the functioning of the Terminal. The load on the Terminal power plant is not estimated to increase in the near future and the available space for the additional units will probably never be used.

During its twenty-two years of operation there have been no serious breakdowns or accidents. The longest shut down on electrical load has been for six minutes and was caused by a switch board operator making a mistake. The

total of shut downs in twenty-two years have been six.
This is extremely good as compared to other power plants.

The load factor of the plant, ratio of the average power output to maximum power output equals .75.

The plant required on an average of 1,000,000 Boiler H. P. hours / month, this ranges from 1,600 Boiler H. P. during the winter hours / month to 540,000 Boiler H. P. / month during the summer.

The plant uses the average of 1,000,000 Boiler H. P. hours to pump 700 gallons of water / min. against a pressure of 250 #, compress 3,000 cu. feet of free air / min. to a pressure of 110 # make 48 tons of ice / day, do refrigerating work equivalent to 58 tons of ice / day, and supply an average electrical load of 1100 K. W.

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Professor J. N. G. Nesbit

Mr. Foultz, Chief Engineer

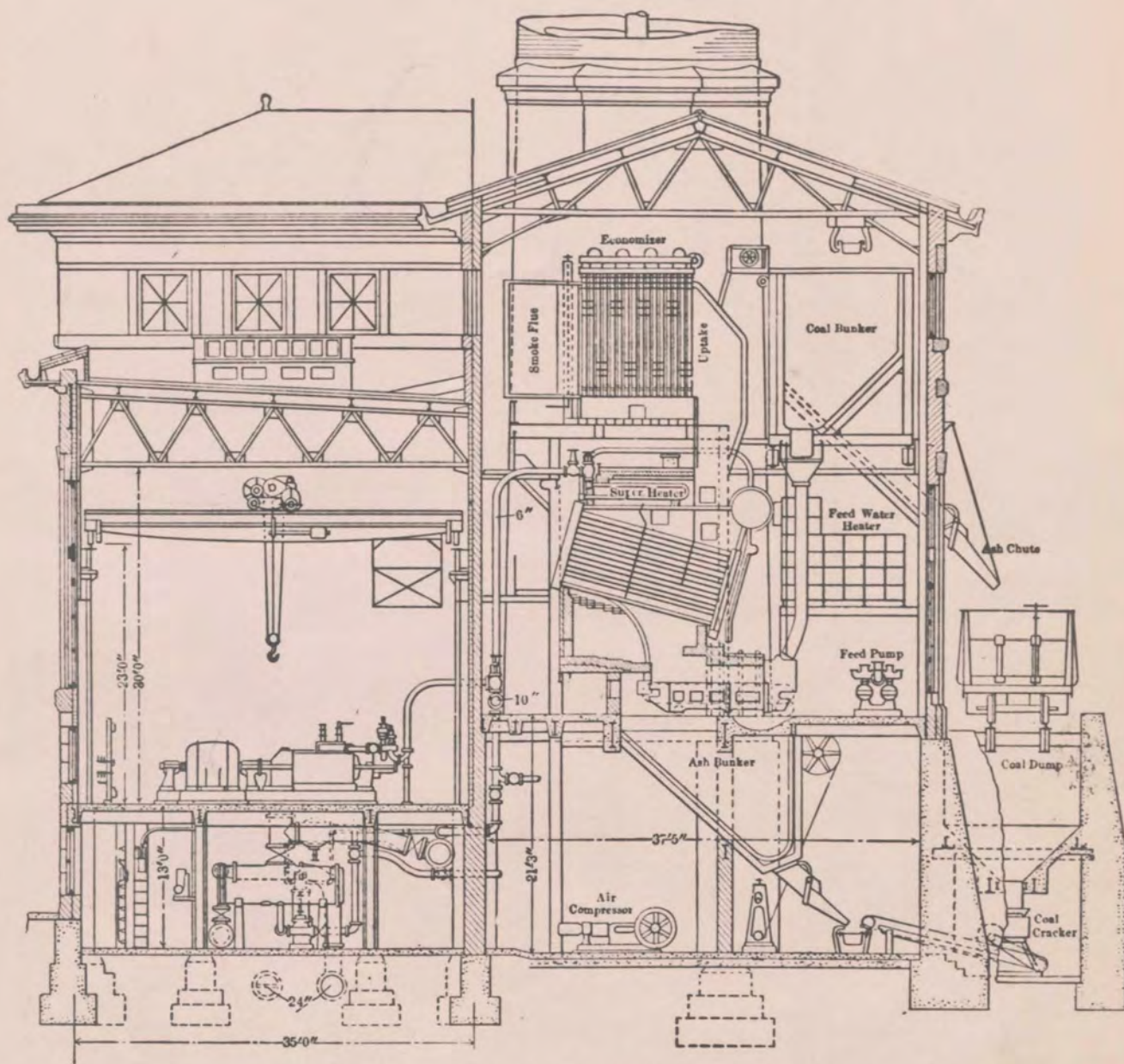
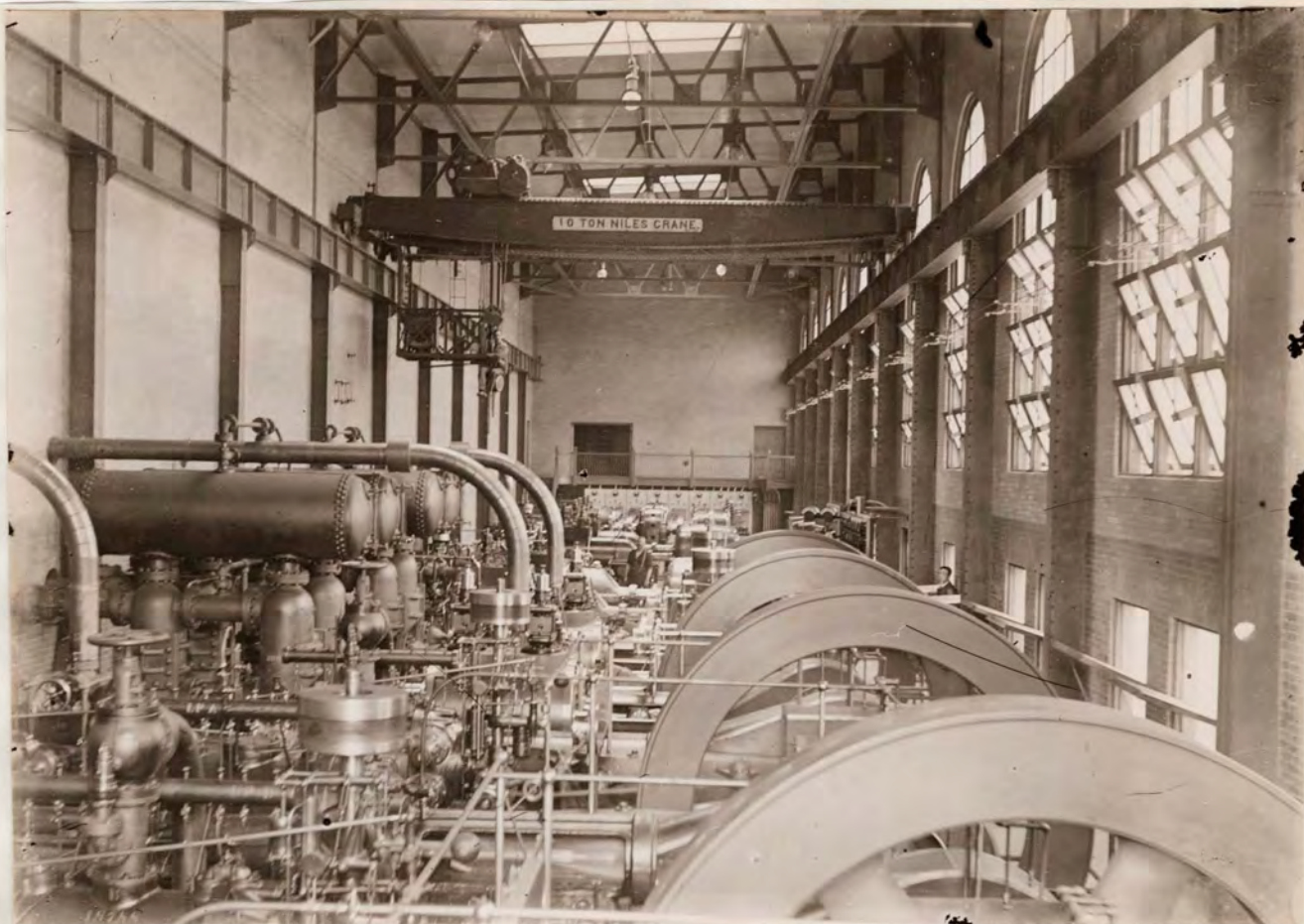


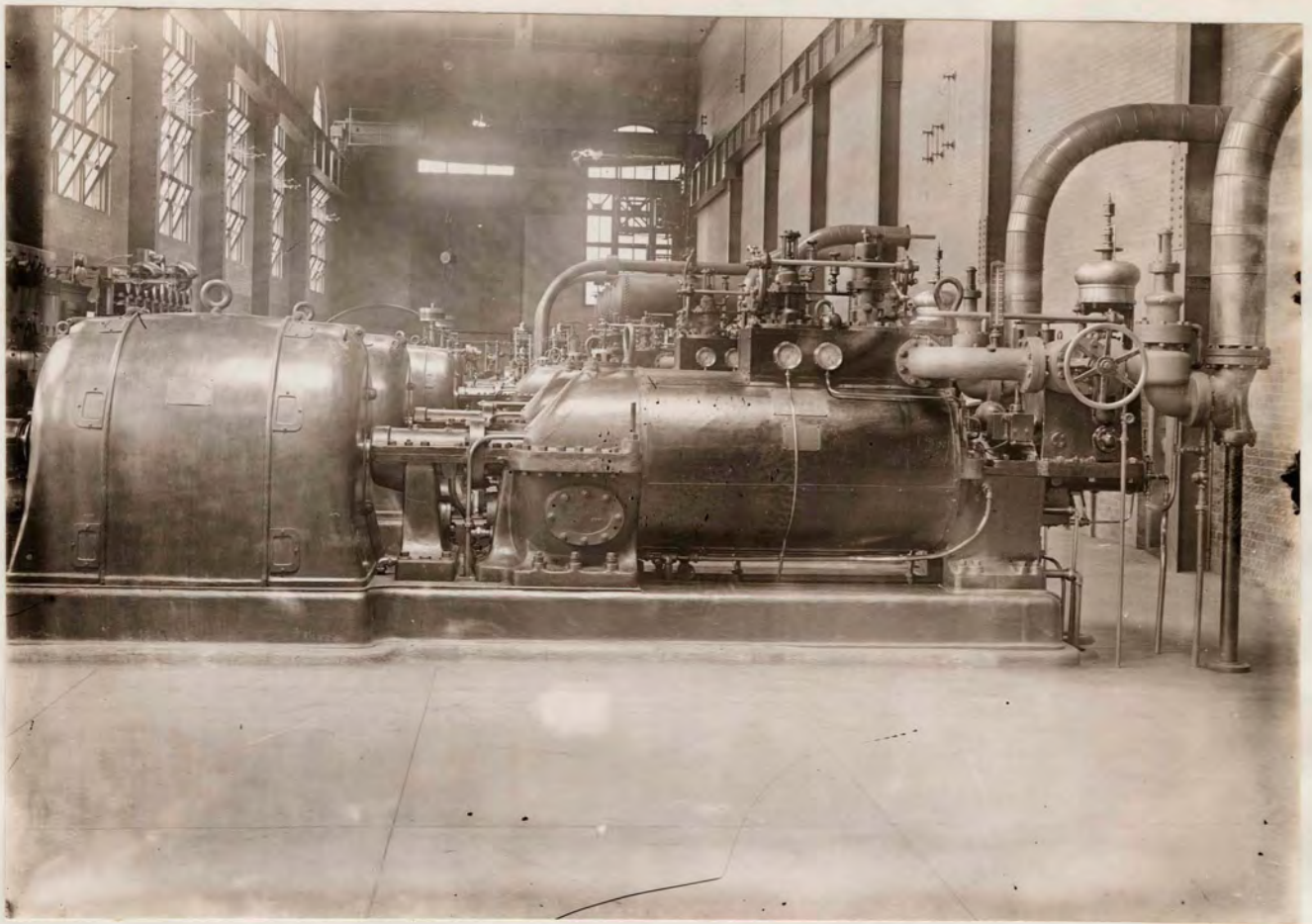
FIG. 2.—CROSS-SECTIONAL ELEVATION OF POWER HOUSE.



Engine Room View



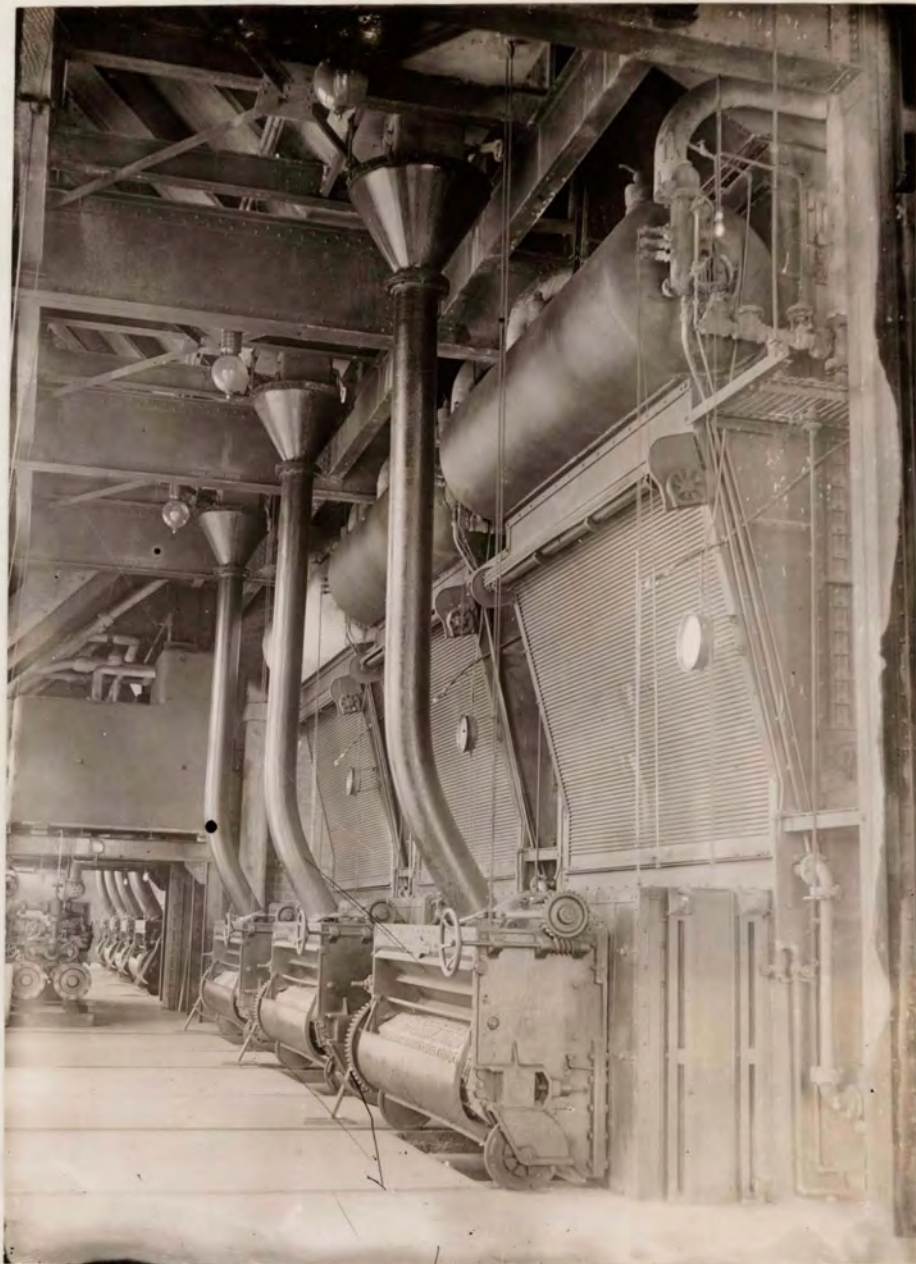
Plant Exterior
East Side



Westinghouse Turbine and Turbo-
Alternator in Engine Room



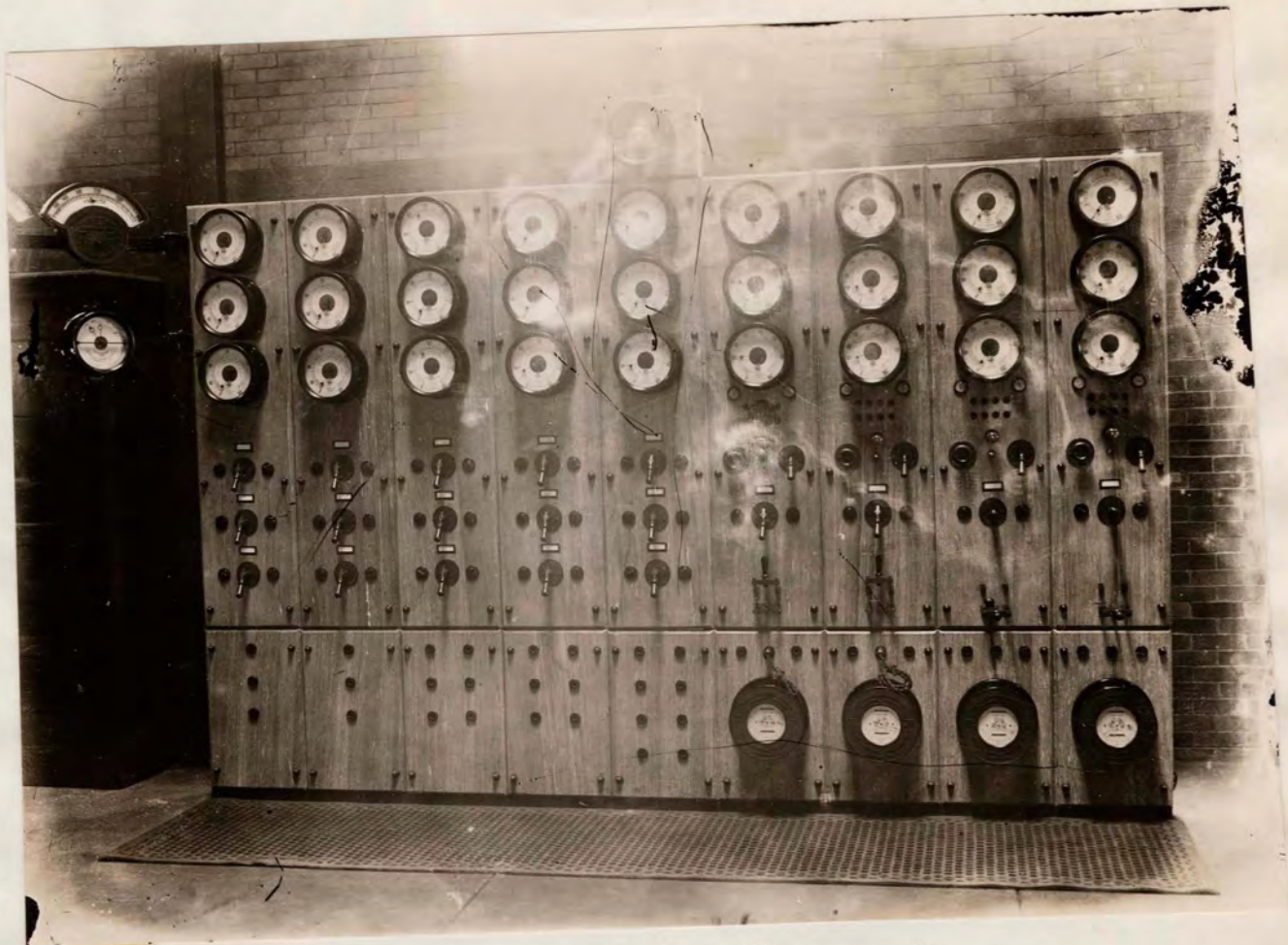
Worthington
Cooling Tower



Babcock-Wilcox Boilers



Nordberg Pumping Engine



A. C. Switch board



*Old Brush Arc
Switch board*